Residential Valuation of Streams in Wake County, N.C.

Denman Glober

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Acknowledgments

Data for residential property variables and open space effects were generously provided by Katherine Henderson, who collected the information for her 2006 master's thesis, "The Effect of Open Space on Residential Property Values in Wake County, NC." Her work has recently been published with Professor Yan Song as "Can nearby open spaces substitute for the size of a property owner's private yard?" (2008) in the *International Journal of Housing Markets and Analysis*.

This project was overseen by Professor Yan Song of the Department of City and Regional Planning at the University of North Carolina – Chapel Hill and would not have been completed without her invaluable assistance.

Executive Summary

This paper investigates the effects of stream presence, type, and amount of streamflow on residential property prices in Wake County, North Carolina sold in 2004. The choice of topic was informed by a rising awareness of water scarcity in the Eastern United States and the growing popularity of market based methods for controlling public goods such as instream water. This paper employs hedonic price modeling, one method of pricing analysis which has not before been applied to the problem of instream flow.

This paper finds that stream flow does matter to residential property owners as expressed by a strong preference for perennial streams (streams with year round flows) over intermittent streams (streams that run dry for parts of the year). This indicates that home prices in Wake County will fall if perennial streams become intermittent due to groundwater depletion or development. **Table 1** summarizes other key findings discussed in the paper.

Table 1. Other Key Findings

Question	Answer
Does distance between stream and parcel centroid (as a proxy for house location) affect value?	For intermittent streams, negative effect at < 100 feet; for perennial streams, positive effect at < 100 feet
Does watershed health affect value?	Location in impacted watershed has a negative effect on value; location in degraded watershed has a positive effect on value
Does the presence of the floodplain affect value?	Location in floodplain has a positive effect on value.
Does streamflow affect value?	Results were insignificant but returned a negative sign for low flow periods across all data sub-sets.

Background

Wake County is located in central North Carolina (**Figure 1**). Growing in population from 423,380 to 627,846 between 1980 and 2000, and with a forecasted 911,000 people by 2010, it is one of the fastest growing counties in the nation (American Fact Finder, U.S. Census Bureau, 2008). With 755 people per square mile in 2000, it is the second densest county in North Carolina after Mecklenburg County. In addition, Wake County's population is above average in education, wealth, and employment (**Table 2**). The combination of rapid population growth and resident wealth and education provides a combination of incentive and means to control the type of growth that the county pursues and how it manages its water resources.

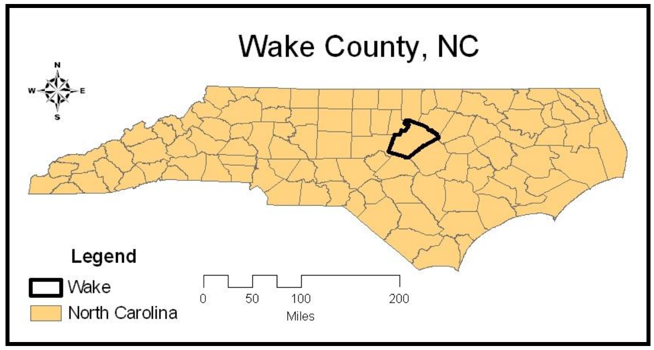

Figure 1. Wake County Location

Table 2. Demographic characteristics of Wake County and U.S. residents (U.S. Census Bureau, 2006)

Characteristic	Wake CO	U.S.
Bachelor's Degree or Higher	45.6%	27%
Median Family Income	$78,369	$58,526
Families below poverty level	5.3%	9.8%
In labor force	70.8%	65%

Wake County residents use primarily surface water for their needs rather than ground water, meaning that they draw water from streams and reservoirs rather than wells[1]. Historically, surface water in North Carolina was captured for agricultural, municipal, and industrial uses, but growing demand has

[1] In 2000, approximately 20% used wells (Wake County Comprehensive Groundwater Investigation, 2003, p. 5-2).

created tension between these and instream flow needs for habitat and recreation. An exceptional drought, defined by the N.C. Division of Water Resources as stream flow at less than 2 percent of the average for that day in previous years, covered Wake County between October, 2007 and April, 2008 highlighting the growing tension between these uses.

Instream flow regulation has only recently become a focus of water regulation in North Carolina. State water planning began in 1989 with the passage of House Bill 157, which required the creation of a state water supply plan. The first plan was not released until 2001, but it emphasizes instream flow protection for habitat, recreation, and water quality. The primary mechanisms described in the plan to protect flow include: transfer of water between river basins, federal requirements for endangered species protection, reservoir release requirements when water withdrawals from a stream exceed 20 percent of the location's 7Q10 flow (the lowest flow for a 7 day period expected in any 10 years), and the Division of Water Quality's ability to regulate withdrawals for water quality reasons. The protection measures in place are complicated by political pressure from growing municipalities, grandfathered rights, and the uncertain effects of climate change.

Passed in 2002, North Carolina General Statute G.S. 143-355(I) requires that all local governments and community water systems that provide water to 1,000 or more service connections or 3,000 or more individuals create a water supply plan and update the plan at least every 5 years. This requirement has only served to highlight the challenge of providing water to Wake County's growing population. By 2010, the populations from five of the 11 jurisdictions that supply water in Wake County will consume at least 80 percent of their projected supply (**Table 3**). In some cases, water is expected from municipalities that do not themselves have sufficient supply to meet their own population's demand. Not only will the surface supply fall under increasing pressure from population demands, but demand will also exceed supply for the private companies that rely on well water[2].

Table 3. Water use as a percent of demand, projections for municipalities in Wake County (North Carolina Department of Environmental and Natural Resources, 2008)

Jurisdictions	**Water Source(s)**	**Future Source(s)**	**Demand as % of Supply**			
			2002	*2010*	*2020*	*2030*
Surface Water						
Apex	Haw River; Purchased from: Raleigh		34	60	81	123
Cary	Haw River; Purchased from Durham, Raleigh, Harnett CO		41	50	67	78
Fuquay-Varina	Purchased from: Raleigh, Harnett CO, Johnston CO	Harnett CO, Johnston CO	28	18	31	53
Holly Springs	Purchased from: Raleigh, Harnett CO	Harnett CO	46	24	47	68
Knightdale	Purchased from: Raleigh	Raleigh	47	134	241	357
Morrisville	Purchased from: Cary, Durham		65	109	140	160
Raleigh	Neuse River	Little River Reservoir, Swift Creek	76	81	96	91
Wake County (RTP South)	Purchased from: Cary		12	170	250	330
Wake Forest	Smith Creek; Purchased from: Raleigh (expired 2007)	Neuse River	42	24	35	51
Wendell	Purchased from: Knightdale/Raleigh, Zebulon		55	111	153	195
Zebulon	Little River	Raleigh	59	39	57	75
Well Water (private businesses)						
Bayleaf Master			53	70	94	126
Leesville Master			59	56	75	101

Study Period

Figure 2 (next page) shows stream gage locations that collected daily streamflow data during 2004. Streamflow in 2004 was slightly below average for

[2] Depending on the geography of a region, ground water either directly supports surface flow and contributes to stream levels, or ground water can substitute as a supply when surface flows are low. In this situation, ground water is not an adequate supply substitute.

the area, as shown by measurements at two locations on Neuse River and Crabtree Creek. At Neuse River near Falls Lake, streamflow was 408 ft^3 per second in 2004, while the average was 635 ft^3 and median was 491 ft^3 between 1983 and 2007. At Crabtree Creek, streamflow was 114 ft^3 per second in 2004, while the average was 125 $ft^3$and median 121 ft^3 between 1998 and 2007.

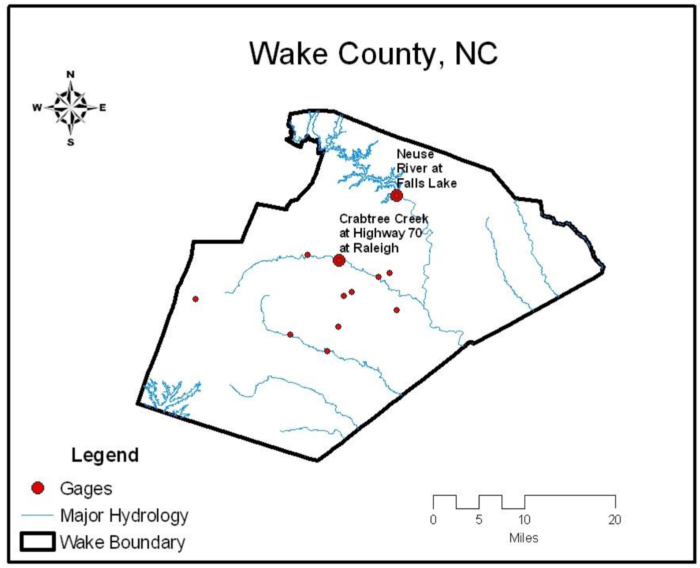

Figure 2. Stream gage locations with Neuse River and Crabtree Creek emphasized

Literature Review

The rising conflict around surface water use emphasizes the importance of discovering how people value streams and stream flow. Existing literature on how people view streams includes both hedonic price modeling and analysis of values and behavior through interviews, aesthetic preference surveys, and contingent valuation models.

Hedonic Price Literature

Hedonic price literature has grown dramatically in the past twenty years and incorporates residential property valuations of everything from open space, to air quality, to deed restrictions. While a fair number of hedonic price analyses have focused on wetlands (e.g. Mahan, Polasky & Adams, 2000) and lakes (e.g. Boyle & Taylor, 2001; Kashian, Eisworth, & Skidmore, 2006;), I found only six studies that explicitly included rivers or streams as a separate category for valuation.

Focusing on urban stream restoration in California, Streiner and Loomis (1995) found that property prices in areas with restored streams increased the mean property value in their study 3% to 13%.

Quayle and Hamilton (1999) concluded in their analysis of residences proximate to riparian greenways in Vancouver, B.C. that proximity to water as a distinct greenway attribute has a positive effect on property values independent of the value added by proximity to the greenways.

Mahan et al. (2000) included streams in an analysis of wetland value and concluded that the marginal implicit price for reducing the distance to the nearest stream by 1,000 feet lends an increase in house value of $258.81. They carried out a second-stage analysis to determine the willingness-to-pay function for the size of the nearest wetland to a residence, but were unable to obtain meaningful results. Reasons they suggest include a lack of meaningful separate markets and difficulty in overcoming endogeneity.

Mooney and Eisgruber (2001) carried out a study based in Portland, Oregon on the cost of riparian stream buffers. Although they concluded that a treed riparian buffer reduces property value, they also found that a $10,777 premium can be ascribed to stream adjacency for the average house in their market area.

Netusil (2005) conducted a hedonic price analysis on the impact of environmental zoning in Portland, Oregon. As part of his analysis, he concluded that while steeply sloped properties with streams will sell for approximately

15.76% less than a level, dry property, trees and a stream will increase the sale price by 12.89%. He also found that a stream flowing within 200 feet but through someone else's private property would reduce the value of the non-stream property. Inversely, if the stream is between 1/4 and 1/2 a mile away, it will increase the value of the non-stream property.

Kopitz, McConnell, and Walls (2007) determined in a study of open space value in rural-urban fringe subdivisions that adjacency to the Patuxent River or Chesapeake Bay added 30% to house prices.

From these hedonic price analyses, we can conclude that the presence of a stream almost invariably raises property value, although the exact amount varies by location. The studies also indicate that stream value can be compromised by closely related amenities and disamenities such as riparian buffers, steep slopes, and exact stream location with respect to residential properties.

Other Valuation Literature

Other stream and river studies fall into two categories: analyses of stream aesthetics using photographs or videos of scenes to create user preference models, and market based analyses using the travel cost or contingent valuation method.

Studies of Stream Aesthetics

Studies of stream aesthetics use photographs or videos of scenes, either on-site or off, to create user preference models. They include comparisons of river scenes with other types of landscapes and comparisons between different types of water and river views. Most studies investigate a set of over a dozen variables that measure preference based on categories such as texture, mystery, and spaciousness, which speak to the rater’s opinion of the scene.

Levin (1977; as cited in Kaplan & Kaplan, 1989) looked at preference for different types of "everyday riverside" view. She used on site and photographic surveys and found an ordered preference for: Vista (view of hill or bend), then Obstructed (overgrown vegetation and narrow river width), then Lakelike (bands of water, land, and sky) river views. While Lakelike scored high for “spaciousness,” it scored low in the categories of “comprehensiveness” and “mystery,” the two criteria that measure viewer involvement. In contrast, Obstructed scored high only in “comprehensiveness,” but this was enough to give it preference over Lakelike.

Ellsworth (1982; as cited in Kaplan & Kaplan, 1989) conducted a study of river and marsh scenes. He concludes that "river scenes rated higher in preference than the marsh scenes. The most preferred river scenes were biophysically diverse and high in Mystery and visual depth. Respondents preferred pastoral settings with curved stream corridors over those with trash, unclear spatial definition, and obscured views" (Kaplan and Kaplan, 1989, p. 221). This closely echoes Levin’s earlier findings.

Likewise using photographs, Herzog (1985) measured aesthetic preference for different waterscapes: Mountain Waterscapes, Large Bodies of Water, Rivers/Lakes/Ponds, and Swampy Areas. His study had 259 introductory psychology students rate 70 colored slides based on seven factors. The students expressed preferences in the order listed above with “spaciousness” both highly preferable and highly predictive of the Mountain

Waterscapes and Large Bodies of Water[3]. Of interest, the “spaciousness” factor lends tentative support to Mooney and Eisgruber’s (2001) finding, described above, that riparian buffers decrease property value.

In aggregate, the above studies suggest that people most prefer river landscapes that draw in the viewer with mystery and clearly defined views.

Partially in response to these earlier studies, Brown and Daniel (1991) studied the relationship between stream flow quantity and scenic beauty through user rated video sequences of the Cache la Poudre River in Colorado. They found that respondents preferred increasing levels of flow up to 1,100-1,500 cubic feet per second (cfs) after which preference decreased. Flow explained 10 to 25 percent of variance in their analysis.

Gregory and Davis (1993) made a study of public perception of stream aesthetics in woodland settings in the U.K. The most favored characteristics were clear water, eroded banks, and depth while the least favored were muddy water, concrete banks, and debris. Gregory and Davis cite a New Zealand study by Mosley (1989), which concludes that people judge a riverscape more by the surrounding landscape, particularly natural forest, than by the river itself. They comment that while forestation was a factor in their study, it was not as predictive as in Mosley’s analysis.

While not invalidating instream flow as an important subject for consideration, these two articles, like Mooney and Eisgruber’s and Herzog’s, indicate that instream flow is only one small factor affecting aesthetic appreciation and valuation of a stream.

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[3] He was surprised that Large Bodies of Water ranked above Rivers/Lakes/Ponds and hypothesized that the demographics of the survey group may have been an influencing factor (college students like beaches).

Other Market Based Models

Daubert and Young (1981) made a study of the recreational value of instream flows on the Cache la Poudre River in Colorado. Through interviews of 149 fishers, boaters, and streamside recreation participants on site and using photographs of the river in different conditions, they created a contingent valuation model of willingness to pay for instream water levels. They found that flow is highly significant to fishers and boaters and less so to stream side users, that fishers and streamside users express a diminishing willingness to pay (up to 500 cfs and 700 cfs respectively) but that boaters did not experience a diminishment with the quantities of water measured, and that in aggregate, the marginal value of instream flow exceeds that of irrigation at relatively low flow periods. They concluded that instream flow does carry value and their analysis suggests that people will pay for instream water even for stream side uses.

Duffield, Christopher, and Brown (1992) created a contingent choice model based on trip valuation and instream flow at Montana's Big Hole and Bitterroot Rivers. Based on interviews with shoreline users and fishers and on the cost of electricity generated by a downstream hydroelectric plant, they estimated a marginal recreational value of instream flow of $50 per acre foot at low-flow levels plus $25 for downstream hydroelectric generation. They found that marginal willingness to pay reaches a maximum at about 1,800 cfs on the Bitterroot and about 2,000 cfs on the Big Hole. From this, they concluded that a reallocation from consumptive (stream withdrawals) to instream water use would be more efficient during most of the period of study.

Walsh *et al.* (1980) in Colorado, Ward (1985) in New Mexico, and Narayanan *et al.* (1983) in Utah (all cited in Loomis, 1986) found comparable marginal willingness to pay for instream flow using variations on the travel cost and contingent valuation models, but they limited their studies explicitly to boaters or fisherman. Each determined that instream flow value was competitive with withdrawal values at 65 to 70 percent bankful.

Although these studies do not focus on the passive or intermittent recreational use of residential users, they do indicate a significant value assigned to instream flow by recreational shoreline users.

Looking at instream value beyond aesthetics and use, Berrens, Bohara, Silva, Brookshire, and McKee (2000) conducted a telephone survey in New Mexico of willingness to pay to protect minimum instream flow to protect endangered fish species in New Mexico's rivers. They found a median willingness to pay of $25 annually per household for protecting the endangered silvery minnow in the Rio Grande and $55 annually per household for protecting 11 other species on four of New Mexico's major rivers.

Although not connected directly to market based valuation or aesthetic preference, Booth, Karr, Schauman, Konrad, Morley, Larson, Henshaw, Nelson, and Burges (2001) assessed the social impacts on stream restoration efforts through a series of interviews, mail surveys, photographs, and aerial images in a massive analysis titled *Urban Stream Rehabilitation in the Pacific Northwest: Physical, Biological and Social Considerations*. In one set of 30 interviews with an even number of creekside residents involved in stream restoration, creekside residents not involved in restoration, and non-creekside residents involved in restoration, 70 percent of responses indicated an emotional connection to the creek. The authors also conclude that:

> "creekside involved" residents most often listed personal connections, aesthetics, flow of the water and their connection to the community as the

> more important creek factors, whereas “creekside non-involved” residents listed property issues and erosion as more important creek factors. The “non-creekside but involved” residents listed education and wildlife habitat as the more important creek components. (p. 48)

From the mailed survey, the greatest response (over 75 percent) to a question about the most important consideration for landscaping or gardening was “low maintenance” (p. 47). Finally, reflecting earlier studies on riparian buffers, they found that buffers generally remained in newer subdivisions but had been removed and not replaced in older neighborhoods and that benches for sitting along the creeks were common in both areas (p. 48). This study reveals a general appreciation for urban streams and pinpoints residential property owners’ particular concerns. Concerns with low maintenance and removal of riparian buffers may support the dislike of obstructed views revealed in the stream aesthetic studies discussed above.

Summary and Conclusions

Hedonic price modeling has been applied to value residential proximity to streams. Aesthetic preference surveys have been applied to compare between stream views and to compare stream views with other landscape views. Contingent choice models and travel choice models have been used to value instream flow levels. All of the studies have concluded that streams have value, that value varies across the location and population surveyed, and that stream flow is one attribute of a stream’s characteristics that will affect human appreciation of stream value. They also indicate that based on aesthetics and recreational use, the marginal utility of instream flow will increase to a point and then decline.

Methods

Three valuation techniques can be used to determine the price people are willing to pay for a good: market based, revealed preference, and stated preference. Market based techniques, while the most accurate, require that the good under consideration be explicitly traded in the market. Revealed preference techniques use market data related to the good under consideration to infer the good's value. Hedonic price analysis is one example of this technique. Stated preference techniques involve asking people the price they would be willing to pay for a good under a particular set of circumstances. Contingent valuation is an example of this technique.

Hedonic price analysis is particularly appropriate for this study as the value of streams to residential property owners (as opposed to the value of water removed from streams) is a good that is not traded explicitly in the market but that can be inferred from existing market data. Unlike other tools used to measure consumer valuation of environmental amenities, hedonic price analysis uses the actual paid price of a good to value characteristics of the good that are not explicitly traded (Freeman, 1993).

The hedonic price method was first popularized for valuing environmental amenities by Ridker and Henning's analysis of air pollution in St. Louis (1967), and it was quickly contributed to and modified by researchers such as Anderson and Crocker (1971), Freeman (1974), and Rosen (1974), whose theoretical study is cited as the basis of most empirical hedonic models. Most commonly, hedonic price analysis has been used to measure the marginal value of air quality (e.g. Ridker & Henning, 1967), water quality (e.g. Leggett &

Bockstael, 2000), noise (e.g. Dale et al. 1999), hazard sites (e.g. Hansen, 2006), open space (e.g. Irwin, 2002; Henderson, 2006), and to a lesser extent water features.

Hedonic price analysis does have limitations. It is used to estimate the approximate value of an environmental amenity or disamenity through a first stage regression of the attribute of interest against the total value of the object of analysis. A second stage analysis can be conducted to generate a willingness-to-pay curve for the consumer and determine upper and lower boundaries for the value, but this requires comparisons between multiple markets in the study area. The method also carries assumptions of a perfect market: perfect information, free movement, free entry, etc. As Netusil (2005) and Mahan et al (2000) point out, there are also benefits to environmental amenities such as downstream water quality improvements, biodiversity, and groundwater recharge that may not be captured in the market if the services provided are public goods or if they are not fully perceived by the consumer. Nevertheless, the method can be a useful tool for demonstrating the value of an environmental amenity when carefully applied.

The hedonic price function regresses the attributes of individual land parcels against the prices of the parcels. The basic hedonic price of a good can be expressed as:

PHi = f(S-il ,…,S-iJ, N-il ,…, N-iK, A-il,…,A-iL, Q-il,…,Q-iM, time-i)

In this example, for each house i, PH is the price, SJ represents structural characteristics, NK represents neighborhood characteristics, AL represents accessibility, QM represents environmental characteristics, and time is the date of the sale (Henderson, 2006).

Questions for Analysis

As different information was available for different levels of analysis, I ran analysis on three sets of data. Each data set has its own set of questions, shown in **Table 4**. After describing the data sources and variables used in the analysis, I discuss the results of the analysis of each set of data separately. The data interpretation section contains a discussion of the results across data sets.

Table 4. Data sets and accompanying questions

Data Set	# of Parcels	Questions
All Parcels	14,542	Does the presence of a stream affect value?
		Does the type of stream affect value?
		Does the health of the watershed affect value?
		Does the month of sale affect value?
Parcels with Streams	1,790	Does the type of stream affect value?
		Does the distance between centroid and stream affect value?
		Does the health of the watershed affect value?
Parcels streams for which stream flow data is available	380	Does the amount of stream flow affect value?

Variables

This section contains information on the control variables used for analysis. The first section contains Katherine Henderson's (2006) data tables and a summary explanation of her variables. The second section contains a description and explanation of the variables I gathered to supplement her data. The dependent variable throughout this study is the natural log of the house price.

Section 1: Henderson Variables

Henderson (2006) compiled a set of control variables such as house size and age that clearly effect residential property value, described in **Table 5** (next page), and a set of variables specific to her study of open space, described in **Table 6** (next page).

In **Table 6**, the "Other" open space category includes seven types of open space that returned inconsistent results when enumerated separately but consistent results once combined. She explains that the category is comparable to similar combined open space categories in other studies (Henderson, 2006, 21). The "DIST_PUB" category is a continuous variable while "BUFFER_PUB" is a binary variable set at 1500 feet. Finally, the "Interaction" variable relates backyard size to the value of nearby open space. She further limited each set of variables according to the following list:

Residential Property Characteristics (adapted from Henderson, 2006, p. 25)

- Sales Date
- Sales Price
- Single-family residential classification
- Less than 10 acres
- Living space greater than 600 square feet
- Parcel size greater than 0.1 acres, less than 5 acres
- Built after 1944
- Sales price more than 60% or less than 160% of total assessed value
- Assessed value of the land greater than US $1.00 per square foot
- Assessed value of improvements greater than US $25 per square foot
- Individual ownership
- Detached units

Table 5. Control Variables from Henderson (2006, p. 20)

Variable Name	Description	Unit
Structural Characteristics		
BATHS	Number of bathrooms	# of bathrooms
HEATEDAREA	Heated area	Square feet
LOT_SIZE	Lot size	Acre
FOOTPRINT	House footprint	Square feet
AGE	Age	Year
AIR_YN	Air conditioning or not	Binary
STORIES	Number of stories	# of stories
Public Sector Characteristics		
INCITY	Within a municipality or not	Binary
RD_YN	Within 500 ft of major road or not	Binary
Neighborhood Characteristics		
HOUSEHOLDS	Median household income in census block group (2000)	Dollar
PCT_NONWH	Percentage of non-white residents in census block group (2000)	Percentage
DENSITY	Density: number of people in census block group (2000) divided by block group area	# of people/acre
Regional Accessibility Characteristics		
DIST_CENTER	Distance to nearest major regional activity center	Yard

Table 6. Open Space Variable from Henderson (2006, p.22)

Variable Name	Description	Unit
Proximity to Open Space		
DIST_GOLF	Distance to nearest golf course	Yard
DIST_PUB and BUFFER_PUB	Distance to nearest public open space	Yard
DIST_OTHER	Distance to nearest "other" open space	Yard
Size of Nearest Open Space		
SIZE_GOLF	Size of nearest golf course	Acre
SIZE_PUB	Size of nearest public open space	Acre
SIZE_OTHER	Size of nearest "other" open space	Acre
Interaction Variable		
INTERACTION	(Distance to nearest public open space) x (Lot size – (house footprint/43560))	Yard*Acre

Section 2: Stream Variables

Table 7 (next page) lists variables that I created to assess the impact of stream presence, distance from stream, stream flow, floodplain presence, watershed quality, and month of sale.

Table 7. Variables relating to streams and stream flow

Variable Name	Description	Unit
Stream Proximity		
PEREN_INT	Presence of a perennial stream on the parcel	Binary
INT_INT	Presence of an intermittent stream on the parcel	Binary
MAJHY_INT	Presence of major hydrology on the parcel	Binary
PEREN_5FT	A perennial stream within 5 feet of the parcel centroid	Binary
INT_5FT	An intermittent stream within 5 feet of the parcel centroid	Binary
MAJHY_5FT	Major hydrology within 5 feet of the parcel centroid	Binary
PEREN_10FT	A perennial stream within 10 feet of the parcel centroid	Binary
INT_10FT	An intermittent stream within 10 feet of the parcel centroid	Binary
MAJHY_10FT	Major hydrology within 10 feet of the parcel centroid	Binary
PEREN_25FT	A perennial stream within 25 feet of the parcel centroid	Binary
INT_25FT	An intermittent stream within 25 feet of the parcel centroid	Binary
MAJHY_25FT	Major hydrology within 25 feet of the parcel centroid	Binary
PEREN_50FT	A perennial stream within 50 feet of the parcel centroid	Binary
INT_50FT	An intermittent stream within 50 feet of the parcel centroid	Binary
MAJHY_50FT	Major hydrology within 50 feet of the parcel centroid	Binary
PEREN_100FT	A perennial stream within 100 feet of the parcel centroid	Binary
INT_100FT	An intermittent stream within 100 feet of the parcel centroid	Binary
MAJHY_100FT	Major hydrology within 100 feet of the parcel centroid	Binary
PEREN_300FT	A perennial stream within 300 feet of the parcel centroid	Binary
INT_300FT	An intermittent stream within 300 feet of the parcel centroid	Binary
MAJHY_300FT	Major hydrology within 300 feet of the parcel centroid	Binary
Floodplain Presence		
Floodplain	Presence of floodplain on the parcel	Binary
100YR	Presence of the hundred year floodplain on the parcel	Binary
500YR	Presence of the five hundred year floodplain on the parcel	Binary
Watershed Health		
Healthy	Parcel located within a watershed listed as "Healthy" by Wake County (2002)	Binary
Impacted	Parcel located within a watershed listed as "Impacted" by Wake County (2002)	Binary
Degraded	Parcel located within a watershed listed as "Degraded" by Wake County (2002)	Binary
Streamflow (on parcels for which gage information was available)		
FL_Oneone	Average stream flow between 30 and 60 days prior to sale date	Percent
FL_Twoone	Average stream flow between 30 and 90 days prior to sale date	Percent
FL_Onetwo	Average stream flow between 60 and 90 days prior to sale date	Percent
Month of Sale		
month_mean	The month in which the parcel was sold	Month

Stream information for perennial and intermittent streams comes from data created in June, 2000 by Wake County Environmental Services Classifications were originally based on USGS topographic map assignments and edited using aerial photography. For the purposes of this study, I eliminated false connectors in the shapefile and created new shapefiles based on classifications of the stream segments as intermittent or perennial in the original file.

Stream information for major hydrology comes from the NC Center for Geographic Information and Analysis and was created between 1997 and 1999. Major hydrology includes Neuse River, Beaverdam Creek, Basal Creek, Black Creek, Black River, Buckhorn Creek, Buffalo Creek, Crabtree Creek, Little River, Middle Creek, Moccasin Creek, Swift Creek, and Turkey Creek. Only nine parcels intersect major hydrology.

I assigned binary values to the parcels for Stream Proximity, Floodplain Presence, and Watershed Health, adding fields in GIS to my parcel layer, selecting parcels that fit each attribute and assigning a 1 to the field for those parcels (leaving the remaining parcels with a 0 for that attribute).

I approximated distance from stream using the parcel centroid as a proxy for house location.

I included month of sale as a distinct variable in anticipation of a relationship between streamflow and time of year that I did not want masked by time of sale. For month of sale, I created a new field in the parcel layer called MONTH, and assigned a number to each parcel corresponding to month of sale. In STATA, I then created a new variable called month_mean that substitutes the numerical month with the mean of the log of the sale price for that month.

Streamflow is measured in cubic feet per second. In order to include all of the properties for which I had stream flow data, I first took the average from each day provided by USGS and recalculated it as a percentage of the maximum stream flow day for the year. Streamflow is also difficult because the date of sale is rarely the date on which the buyer views the property. As I wanted to capture the effect of streamflow on the buyer, I estimated the probable flow on the viewing date(s). Legal Home Forms, among others, estimates the typical time period between purchase agreement and date of sale at 30 to 45 days in North Carolina. Factoring in additional time to reach a purchase agreement, I considered the average streamflow between 30 and 60 days prior to purchase as the most probable flow amount.

Floodplain information came from the North Carolina Floodplain Mapping Program, North Carolina Division of Emergency Management, which creates and maintains shapefiles for use by FEMA. The data was published in April, 2005.

Watershed health was included as a way to incorporate information on stream attributes such as riparian buffer, bank cutting, and water quality not captured in other data sets. Information on watershed health comes from the Wake County Watershed Management Classification Map, dated to 2002 and part of the Wake County Watershed Management Plan. I used this map to modify a shapefile of river basins and sub-basins provided by the USDA, Natural Resources Conservation Service. A comparison of the watershed management plan map and the modified map I created for analysis can be seen in **Figure 3** (next page). The sub-basins designated by the USDA largely correlated to the watersheds designated in the Wake County study; however, I did create nine new polygons where watershed quality changed within a sub-basin.

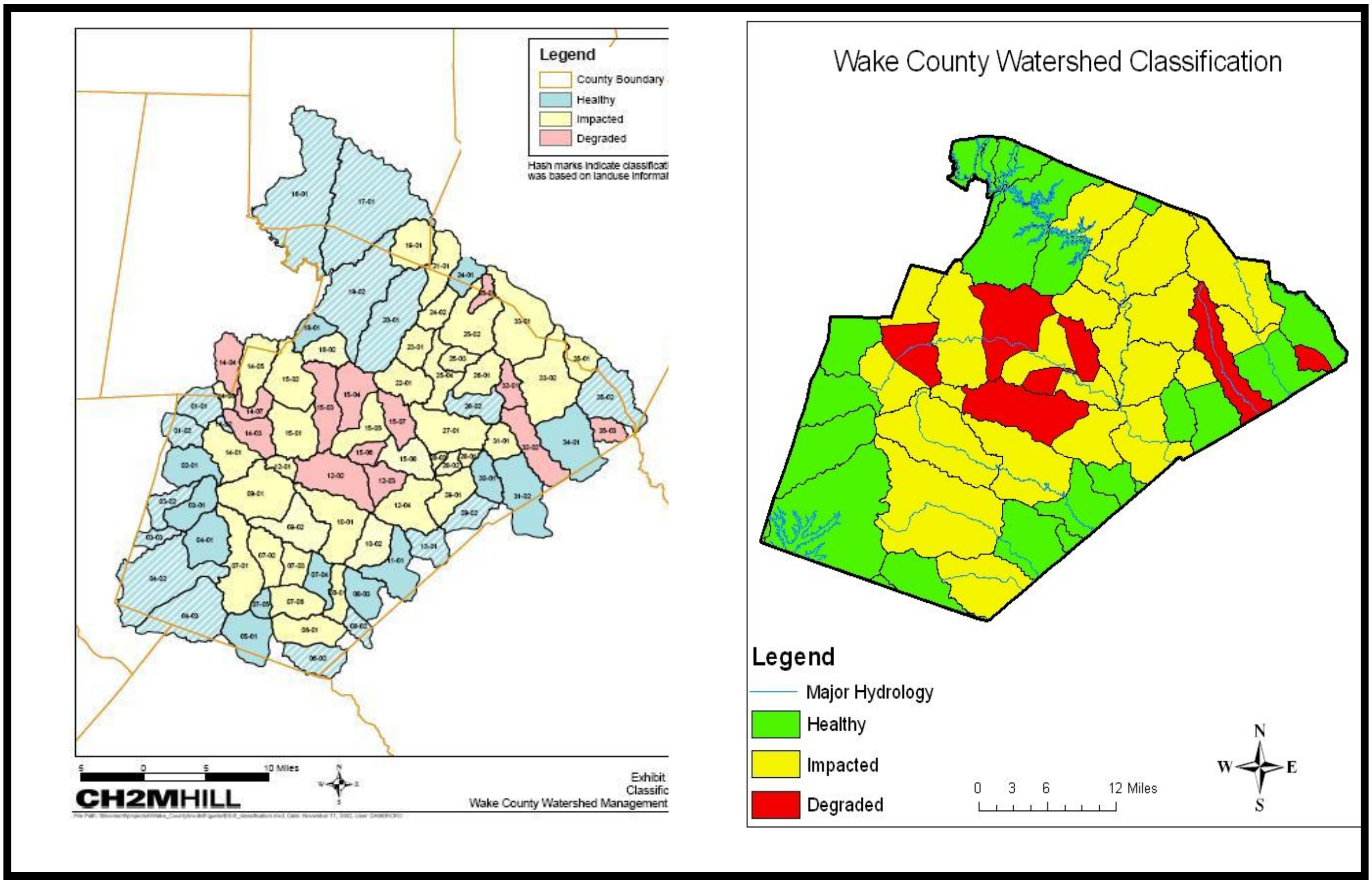

Figure 3. Watershed Plan map and analysis map.

Wake County classified watersheds based on biological, chemical, and impervious surface. **Table 8** (next page) describes the criteria for each classification and more detailed descriptions of their methodology can be found in Technical Manual 7 (Wake County, 2002). In addition to the criteria listed, watersheds were moved to the Impacted category if habitat scored less than 95 or channel morphology indicated an unstable channel (with habitat usually taking precedence). Habitat was assessed using the Mecklenburg Habitat Assessment Protocol. It included an assessment of riparian and stream physical conditions. A score of 100 or less earned a “Fair” condition for an Impacted stream. Greater than 100 earned between “Good-fair” and “Excellent” for a Healthy stream. In other words, biological and chemical ratings took precedence over impervious surface area, while a poor score on habitat (which included riparian buffer) lowered the watershed's rating.

Table 8. Wake County watershed health classification (2002)

Health	Biological	Chemical	Imperviousness
Healthy	Excellent/Good/ Good-Fair rating	<10% water quality violations (with some exceptions)	<10% or healthy on biological
Impacted	Fair rating	10% - 25% violations (with some exceptions)	10% - 25%, but rating on other categories takes precedence
Degraded	Poor rating	>25% violations (with some exceptions)	>25% and no other data

Results

In this section, I discuss the results of analysis for the three sets of data: all parcels, parcels with streams, and parcels for which stream flow data is available.

Data Set 1: All Parcels

The All Parcels data set includes 14,542 properties. **Table 9** lists descriptive statistics for the data set. The questions addressed with this data set include:

- Does the month of sale affect value?
- Does the presence of the floodplain affect value?
- Does the presence of a stream affect value?
- Does the type of stream affect value?
- Does watershed health affect value?

Table 9. Descriptive Statistics for the All Parcels data set

Variable Name	Unit	Mean	Standard Deviation	Minimum	Maximum
lnsalpric	Ln(dollar)	12.26	0.48	10.2	14.48
baths	# of bathrooms	2.52	0.53	1	3.5
heatedarea	Square feet	2245.29	856.35	624	8658
lot_size	Acre	0.33	0.23	0.1	2.84
footprint	Square feet	1955.65	652.43	576	7016
age	Year	10.81	12.90	1	60

air_yn	Binary	0.99	0.11	0	1
stories	# of stories	1.63	0.44	1	3
pct_nonwh	Percentage	0.24	0.17	0.01	1
density	# of people/acre	2.00	1.85	0.01	17.73
in_city	Binary	0.86	0.35	0	1
rd_yn	Binary	0.02	0.14	0	1
households	Dollar	66329.14	19993.79	9338	146756
dist_act	Feet	11150.65	6104.631	432.8	44448.4
dist_golf	Yard	10665.59	5815.693	151.84	34699.4
size_golf	Acre	194.35	144.75	15.01	530.57
dist_pub	Yard	3536.90	2772.22	32.93	20308.2
size_pub	Acre	154.12	1292.66	0.02	18441.8
dist_other	Yard	467.59	331.99	12.42	2717.66
size_other	Acre	3.91	14.67	0	186.71
interact	Acre*Yard	1223.90	2221.20	2.64	34724.3
month_mean	Mean of ln(dollar)	12.27	0.0225114	12.22	12.30
water_yn	Binary	0.12	0.33	0	1
peren_int	Binary	0.05	0.22	0	1
int_int	Binary	0.08	0.27	0	1
majhy_int	Binary	0.00	0.03	0	1
floodplain	Binary	0.03	0.18	0	1
healthy	Binary	0.20	0.40	0	1
impacted	Binary	0.65	0.48	0	1
degraded	Binary	0.15	0.36	0	1

Table 10 (next page) shows the results of an Ordinary Least Squares (OLS) regression including variables for month of sale and presence of the floodplain. I examine stream presence separately because of multicolinearity issues. Month of sale is positive (as shown in **Figure 4**, next page) and significant at the 1% level. Floodplain presence is positive and significant at the 1% level. Distance to activity centers and size of other open spaces are not significant, in agreement with Henderson's results (Henderson, 2006, 30).

Table 10. OLS Regression results for month of sale and floodplain presence

Variable Name	Estimate	Significance
(Constant)	6.519011	***
baths	0.1236662	***
heatedarea	0.000245	***
lot_size	0.0688339	***
footprint	0.000222	***
age	-0.0016038	***

air_yn	0.112614	***
stories	0.0867158	***
pct_nonwh	-0.4064916	***
density	0.0118353	***
in_city	0.0499673	***
rd_yn	-0.045971	***
households	7.22e-07	***
dist_act	-3.95e-07	
dist_golf	-1.75e-06	***
size_golf |	0.0001114	***
dist_pub	-5.03e-06	***
size_pub	6.20e-06	***
disto_othe	-0.0000181	***
size_other	-0.0001695	
interact	8.00e-06	***
month_mean	0.341715	***
floodplain	0.0238237	***

*** Significance at 1%
** Significance at 5%
* Significance at 10%

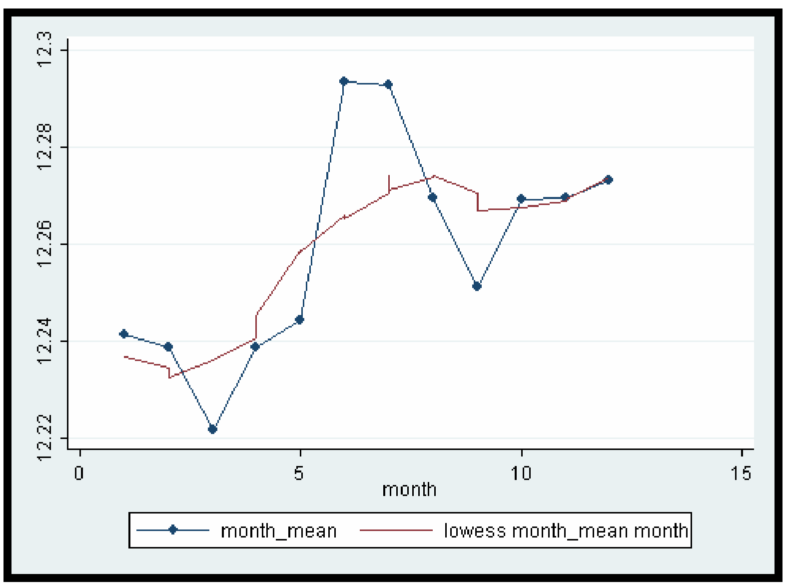

Figure 4. Graph of the log of the sales price by month of sale.

Table 11 (next page) shows the results of regressions run for presence of water and type of stream. The presence of a perennial stream has a positive effect on value significant at the 10% level. The presence of water has no significance, the presence of an intermittent stream has a negative sign but low significance (18% level) and the presence of major hydrology has no significance.

Table 11. OLS Regression results for type of stream

Variable Name	Estimate	Significance
(Constant)	6.523342	***
baths	0.1233154	***
heatedarea	0.0002453	***
lot_size	0.0681881	***
footprint	0.0002221	***
age	-0.0016012	***
air_yn	0.1121646	***
stories	0.0867075	***
pct_nonwh	-0.4069163	***
density	0.0117883	***
in_city	0.0502638	***
rd_yn	-0.0462726	***
households	7.20e-07	***
dist_act	-3.73e-07	
dist_golf	-1.79e-06	***
size_golf |	0.0001108	***
dist_pub	-5.17e-06	***
size_pub	6.27e-06	***
disto_othe	-0.000018	***
size_other	-0.0001632	
interact	8.06e-06	***
month_mean	0.3414926	***
peren_int	0.0123571	*

*** Significance at 1%
** Significance at 5%
* Significance at 10%

Table 12 (next page) shows the OLS regression results for watershed health. Location in a healthy watershed has no significance. Location in an impacted watershed has a negative impact at the 1% level. Location in a degraded watershed has positive significance at the 1% level. Also notable, inclusion of the degraded variable makes distance to activity centers negative and significant at the 5% level.

Table 12. OLS regression results for watershed health

Variable Name	**Healthy**		**Impacted**		**Degraded**	
	Estimate	Significance	Estimate	Significance	Estimate	Significance
(Constant)	6.518437	***	6.511144	***	6.545996	***
baths	0.1233778	***	0.1237224	***	0.1227932	***
heatedarea	0.0002455	***	0.000245	***	0.0002447	***
lot_size	0.0714827	***	0.0731549	***	0.0650134	***
footprint	0.0002215	***	0.0002215	***	0.0002213	***
age	-0.001628	***	-.0016306	***	-0.0018106	***
air_yn	0.1116975	***	0.1155418	***	0.1120641	***
stories	0.086351	***	0.0870125	***	0.0874836	***
pct_nonwh	-0.4067959	***	-0.4106183	***	-0.4162215	***
density	0.0115988	***	0.0105535	***	0.0075965	***
in_city	0.0503218	***	0.0528613	***	0.0468332	***
rd_yn	-0.0460133	***	-0.0484798	***	-0.0505337	***
households	7.35e-07	***	7.12e-07	***	8.99e-07	***
dist_act	-4.46e-07		-2.31e-07		-6.99e-07	**
dist_golf	-1.57e-06	***	-2.89e-06	***	-1.96e-06	***
size_golf	0.0001119	***	0.0001044	***	0.0001071	***
dist_pub	-5.16e-06	***	-4.60e-06	***	-4.88e-06	***
size_pub	6.21e-06	***	6.31e-06	***	6.31e-06	***
disto_othe	-0.0000179	***	-0.0000163	***	-0.0000157	***
size_other	-0.0001677		-0.0001459		-0.0001669	
interact	8.11e-06	***	6.76e-06	***	8.13e-06	***
month_mean	0.3418931		0.3446579		0.339992	
healthy	-0.0058886					
impacted			-.0283793	***		
degraded					.0564465	***

*** Significance at 1%
** Significance at 5%
* Significance at 10%

Data Set 2: Parcels with Streams

The Parcels with Streams data set includes 1,790 variables. **Table 13** (next page) lists descriptive statistics for this data set. The questions to be addressed with this data set include:

- Does the type of stream affect value?
- Does the distance between centroid and stream affect value?
- Does watershed health affect value?

Table 13. Descriptive statistics for parcels that intersect streams data set

Variable Name	Unit	Mean	Standard Deviation	Minimum	Maximum
lnsalpric	Ln(dollar)	12.37	0.51	10.92	14.36
baths	# of bathrooms	2.636872	0.5406694	1	3.5
heatedarea	Square feet	2456.888	988.9654	732	8658
lot_size	Acre	0.4353799	0.3430939	0.1	2.84
footprint	Square feet	2056.083	740.9028	650	7016
age	Year	9.582682	11.77484	1	57
air_yn	Binary	0.9949721	0.0707492	0	1
stories	# of stories	1.672486	0.4124308	1	2.5
pct_nonwh	Percentage	0.2390894	0.1711138	0.01	1
density	# of people/acre	1.895682	1.79597	0.01	17.73
in_city	Binary	0.8502793	0.3568971	0	1
rd_yn	Binary	0.0206704	0.1423181	0	1
households	Dollar	67158.07	21862.89	15703	146756
dist_act	Feet	11307.2	6142.951	813.86	44448.4
dist_golf	Yard	10684.12	5844.437	196.35	34699.4
size_golf	Acre	191.4849	144.0008	15.01	530.57
dist_pub	Yard	3620.334	2808.863	116.64	18592
size_pub	Acre	158.6711	1385.095	0.02	18441.8
dist_other	Yard	478.2136	353.8451	26.55	2194.79
size_other	Acre	2.844877	9.338377	0	167.94
interact	Acre*Yard	1725.344	3041.676	16.18212	34724.26
month_mean	Mean of ln(dollar)	12.36806	0.0444569	12.27237	12.42047
peren_int	Binary	0.401676	0.4903741	0	1
int_int	Binary	0.6150838	0.4867115	0	1
majhy_int	Binary	0.0050279	0.0707492	0	1
floodplain	Binary	0.0743017	0.2623345	0	1
hundredyr	Binary	0.0625698	0.2422553	0	1
fivehunyr	Binary	0.0631285	0.2432619	0	1
healthy	Binary	0.2184358	0.4133001	0	1
impacted	Binary	0.6011173	0.4898054	0	1
degraded	Binary	0.1804469	0.3846667	0	1
int_5ft	Binary	0.024581	0.1548876	0	1
peren_5ft	Binary	0.0067039	0.0816253	0	1
majhy_5ft	Binary	0	0	0	1
int_10ft	Binary	0.0458101	0.2091314	0	1
peren_10ft	Binary	0.0106145	0.1025072	0	1
majhy_10ft	Binary	0	0	0	1
int_25ft	Binary	0.1212291	0.3264845	0	1
peren_25ft	Binary	0.0379888	0.1912227	0	1
majhy_25ft	Binary	0.0005587	0.023636	0	1
int_50ft	Binary	0.3083799	0.4619534	0	1
peren_50ft	Binary	0.1268156	0.3328593	0	1
majhy_50ft	Binary	0.0011173	0.033417	0	1
int_100ft	Binary	0.5608939	0.4964168	0	1
peren_100ft	Binary	0.3536313	0.47823	0	1

majhy_100ft	Binary	0.003352	0.0578151	0	1
int_300ft	Binary	0.7078212	0.4548911	0	1
peren_300ft	Binary	0.5268156	0.4994199	0	1
majhy_300ft	Binary	0.0094972	0.0970168	0	1

Table 14 shows the results of the OLS regression for type of stream. Reflecting the results for the entire set of parcels (positive at 10%), presence of a perennial stream is positive and significant at the 5% level. Presence of an intermittent stream is negative at the 5% level. Major hydrology has no significance.

Table 14. OLS regression results for type of stream

Variable Name	Intermittent		Perennial	
	Estimate	Significance	Estimate	Significance
(Constant)	8.774093	***	8.760183	***
baths	0.1384936	***	0.1384563	***
heatedarea	0.0001997	***	0.0001999	***
lot_size	0.0746446	***	0.0729197	***
footprint	0.0002364	***	0.0002364	***
age	-0.0024165	***	-0.0024102	***
air_yn	-0.0774551		-0.0773938	
stories	0.1258942	***	0.1258252	***
pct_nonwh	-0.4173274	***	-0.4168339	***
density	0.0005143		0.0005483	
in_city	0.0366651	**	0.0359377	**
rd_yn	-0.0584506	**	-0.0581048	**
households	1.64e-07		1.62e-07	
dist_act	-8.47e-07		-8.59e-07	
dist_golf	-4.47e-06	***	-4.46e-06	***
size_golf |	0.0001656	***	0.0001662	***
dist_pub	-1.26e-06		-1.26e-06	
size_pub	8.48e-06	***	8.53e-06	***
disto_othe	0.0000325	**	0.0000326	**
size_other	-0.0008378	*	-0.000849	*
interact	1.42e-06		1.42e-06	
month_mean	0.177271	*	0.1768362	*
int_int	-0.0198426	**		
peren_int			0.019984	**

*** Significance at 1%
** Significance at 5%
* Significance at 10%

Table 15 shows the results for OLS regressions of distance between parcel centroid (approximating house location) and stream. I ran binary regressions for buffers at 5 feet, 10 feet, 25 feet, 50 feet, 100 feet, and 300 feet for each type of stream. The mean parcel size for this data set is 0.435 acres, or 138 feet squared, and the maximum size is 352 feet squared. Distance from intermittent streams is negative and significant at the 10% level for 100 feet. Distance from perennial streams is positive and significant at the 10% level for 100 feet and 5% for 300 feet. Distance from major hydrology is insignificant.

Table 15. OLS regression results for distance between parcel centroid and stream

Variable Name	**Intermittent**		**Perennial**			
	Estimate	Significance	Estimate	Significance	Estimate	Significance
(Constant)	8.811052	***	8.763425	***	8.794258	***
baths	0.1384885	***	0.1382472	***	0.1384998	***
heatedarea	0.0001999	***	0.0001997	***	0.0001998	***
lot_size	0.0694954	***	0.0764596	***	0.0713131	***
footprint	0.000236	***	0.0002371	***	0.0002372	***
age	-0.0024573	***	-0.0023978	***	-0.002418	***
air_yn	-0.0771151		-0.0801925		-0.0807507	
stories	0.1249445	***	0.125729	***	0.1267205	***
pct_nonwh	-0.4172832	***	-0.4175664	***	-0.4153272	***
density	0.0006321		0.0005868		0.001091	
in_city	0.0380749	**	0.0350774	**	0.0351831	**
rd_yn	-0.0570377	*	-0.0600202	**	-0.0611094	**
households	1.74e-07		1.46e-07		1.64e-07	
dist_act	-9.00e-07		-8.49e-07		-8.82e-07	
dist_golf	-4.48e-06	***	-4.46e-06	***	-4.44e-06	***
size_golf	0.0001647	***	0.000165	***	0.0001622	***
dist_pub	-1.34e-06		-1.15e-06		-1.11e-06	
size_pub	8.35e-06	***	8.33e-06	***	8.64e-06	***
disto_othe	0.0000327	**	0.0000326	**	0.0000317	**
size_other	-0.0008398	*	-0.0008647	*	-0.0008522	*
interact	1.60e-06		1.39e-06		1.46e-06	
month_mean	0.1745484	*	0.1768034	*	0.1736627	*
int_100ft	-0.022207	**				
peren_100ft			0.021277	**		
peren_300ft					.0266306	*

*** Significance at 1%
** Significance at 5%
* Significance at 10%

Table 16 shows OLS regression results for the effect of watershed health on value for parcels with streams. I ran the regression for this data set as well as the entire set of parcels as a way of confirming that the watershed health variable would return consistent results. The results were the same, with location in a healthy watershed having no effect and impacted and degraded having a negative effect at a significance of 10%.

Table 16. OLS regression results for watershed health

Variable Name	Healthy		Impacted		Degraded	
	Estimate	Significance	Estimate	Significance	Estimate	Significance
(Constant)	8.622555	***	8.898927	***	9.090967	***
baths	0.1397046	***	0.1400457	***	0.1377757	***
heatedarea	0.0002004	***	0.0002	***	0.0001996	***
lot_size	0.0792174	***	0.0801673	***	0.0771745	***
footprint	0.0002348	***	0.0002332	***	0.0002317	***
age	-0.0023304	***	-0.0025165	***	-0.003071	***
air_yn	-0.0760372		-0.0779894		-0.0963167	
stories	0.1241767	***	0.1212418	***	0.1214484	***
pct_nonwh	-0.4191908	***	-0.4091398	***	-0.4137277	***
density	0.0002518		-0.0033455		-0.0101195	***
in_city	0.0371649	**	0.0437117	**	0.033694	**
rd_yn	-0.0545165	*	-0.0490477	*	-0.0539921	*
households	1.31e-07		1.41e-07		5.38e-07	**
dist_act	-1.01e-06		-3.98e-07		-1.28e-06	
dist_golf	-4.32e-06	***	-6.39e-06	***	-4.71e-06	***
size_golf |	0.0001678	***	0.0001717	***	0.0001613	***
dist_pub	-6.85e-07		-5.25e-07		-3.39e-07	
size_pub	8.21e-06	**	8.32e-06	***	7.98e-06	**
disto_othe	0.0000334	**	0.0000337	**	0.0000382	***
size_other	-0.0008597	*	-0.0008463	*	-0.0008596	*
interact	9.29e-07		-3.17e-07		1.05e-06	
month_mean	0.1884291	**	0.1706403	**	0.1526432	
healthy	-0.0027514					
impacted			-0.0524924	***		
degraded					0.1026298	***

*** Significance at 1%
** Significance at 5%
* Significance at 10%

Data Set 3: Parcels with Flow Data

This section addresses the question: Does the amount of stream flow affect value? The analysis uses Parcels with Flow Data (380 observations) and four data sub-sets: parcels with intermittent streams (210 observations); parcels with perennial streams (178 observations); high-flow parcels with intermittent streams (104 observations); and high-flow parcels with perennial streams (104 observations). High-flow parcels are defined as those with an average daily flow of at least 90 ft^3 per second during 2004.

Although no significant results were returned for these data sets (the greatest significance was at 13% for dry periods under the high-flow sub-set), logical signage was returned (see **Table 17**). In every case, significance was much greater for dry periods than for wet periods.

Table 17. OLS regression results for stream flow

Data Set	**Sign***	
	Wet	Dry
Parcels with Flow Data	+	-
Intermittent Streams	+	-
Perennial Streams	-	-
High-flow Parcels	-	-
High-flow Intermittent	+	-
High-flow Perennial	-	-

* Wet and dry are defined respectively as greater than or less than 20% of the mean flow for the month

Data Interpretation

Does the presence of the floodplain affect value?

Floodplain presence was positive and significant at the 1% level, meaning that the presence of the floodplain on a parcel increased parcel value. This has no obvious explanation. Although the floodplain variable was not highly correlated to any other variables in the regression, it may have captured the effects of multiple variables (such as perennial stream presence and open space) or there may be unknown amenities associated with the variable that yielded a positive sign.

Does the presence of a stream affect value?

Stream presence alone has no effect when applied to all of the parcels sold in 2004.

Does the type of stream affect value?

The presence of a perennial stream on all of the parcels sold in 2004 does have a slight positive effect. Within the set of parcels with streams, perennial streams have a large positive effect while intermittent streams have a large negative effect.

Does distance between stream and parcel centroid affect value?

Intermittent streams have a positive effect when they are further away, and perennial streams have a positive effect when they are closer. For intermittent streams, distance is significant and negative at 100 feet, meaning that the stream has a negative effect on value if it is closer than 100 feet to the parcel centroid. For perennial streams, distance is significant and positive at 100 feet, becoming more significant at 300 feet. This means that a perennial stream always has a more positive effect on value when it is within 300 feet of the centroid than when it is further away and generally has a more positive effect on value when it is within 100 feet than when it is further away.

Does the amount of streamflow affect value?

Although no significant results were returned for the amount of streamflow, signage was consistent and explainable. Across all parcels with flow data, wet periods were positive while dry periods were negative, while across high-flow parcels, both periods were negative. This could be attributed to fear of flooding or other safety and maintenance concerns, although this interpretation would seem to contradict the floodplain variable analysis. For parcels with intermittent streams, wet periods were positive and dry periods negative within both all and high-flow data sub-sets. This could indicate the difference between the positive value of having a running stream on property and the negative value of having a dry ditch.

Does watershed health affect value?

Location in an impacted watershed has a negative effect on value while location in a degraded watershed has a positive effect on value. There is no correlation between degraded quality and dense population or urban location that could explain this effect. One possible explanation is the difference between human appreciation of stream aesthetics and watershed health as measured by Wake County. For example, as discussed above, a riparian buffer can improve a stream's health rating yet decrease its aesthetic value (Mooney and Eisgruber, 2001).

Does the month of sale affect value?

Yes, month of sale affected sales price in all regressions.

Conclusion

The results of this analysis were mostly as expected, and they confirmed, using hedonic price analysis, many of the results found in previous studies through different analysis methods.

With reference to the presence of streams, distance to stream, and amount of stream flow, I found that:

- For parcels sold in 2004: Although stream presence did not have an effect on value, the presence of perennial streams had a positive effect.
- For parcels sold in 2004 with streams: Perennial streams had a positive effect on value; intermittent streams had a negative effect on value. Perennial streams had a positive effect when they were within 100 feet of the parcel centroid, and intermittent streams had a negative effect when they were within 100 feet of the parcel centroid.
- For parcels sold in 2004 with flow data available: Flow had an insignificant effect, but low flow periods had a negative sign across all data sets. High flow periods generally had a positive sign except in high-flow and perennial streams.

These findings indicate that streams do have a positive effect on value if they have constantly flowing water.

I looked at floodplain presence in order to capture possible perceptions of safety and maintenance associated with stream presence and streamflow. I found that floodplain presence was highly significant and positive. The floodplain variable was not highly correlated to any other variables in the regression, but it may have captured the effects of multiple variables (such as perennial stream presence and open space) or there may be unknown amenities associated with the variable that yielded a positive sign.

I looked at watershed health in order to capture aesthetic and water quality concerns unaddressed by other variables. I found that location in an impacted watershed has a significant negative effect on value while location in a degraded watershed has a positive effect on value. As watershed health was not correlated to any other variables, this likely demonstrates a disconnect between aesthetic preferences and watershed health.

Some questions remain around the effects of floodplain presence which are beyond the scope of this study. The effects of streamflow were inconclusive. It may be that choosing a year of more severely high or low streamflows would yield more significant results. This analysis also only included aesthetic effects tangentially, through watershed quality and distance between stream and parcel centroid. Including physical attributes such as stream width and land cover as variables might be possible with GIS and existing orthophotography and could allow a more direct analysis of aesthetic considerations.

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